

Noise Control in WSHP Design

ASHRAE Seminar 28
Sponsored by TC 2.6
Sound & Vibration

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WSHP Noise Sources

- | **Compressors**
 - » Rotary
 - » Reciprocating
 - » Scroll

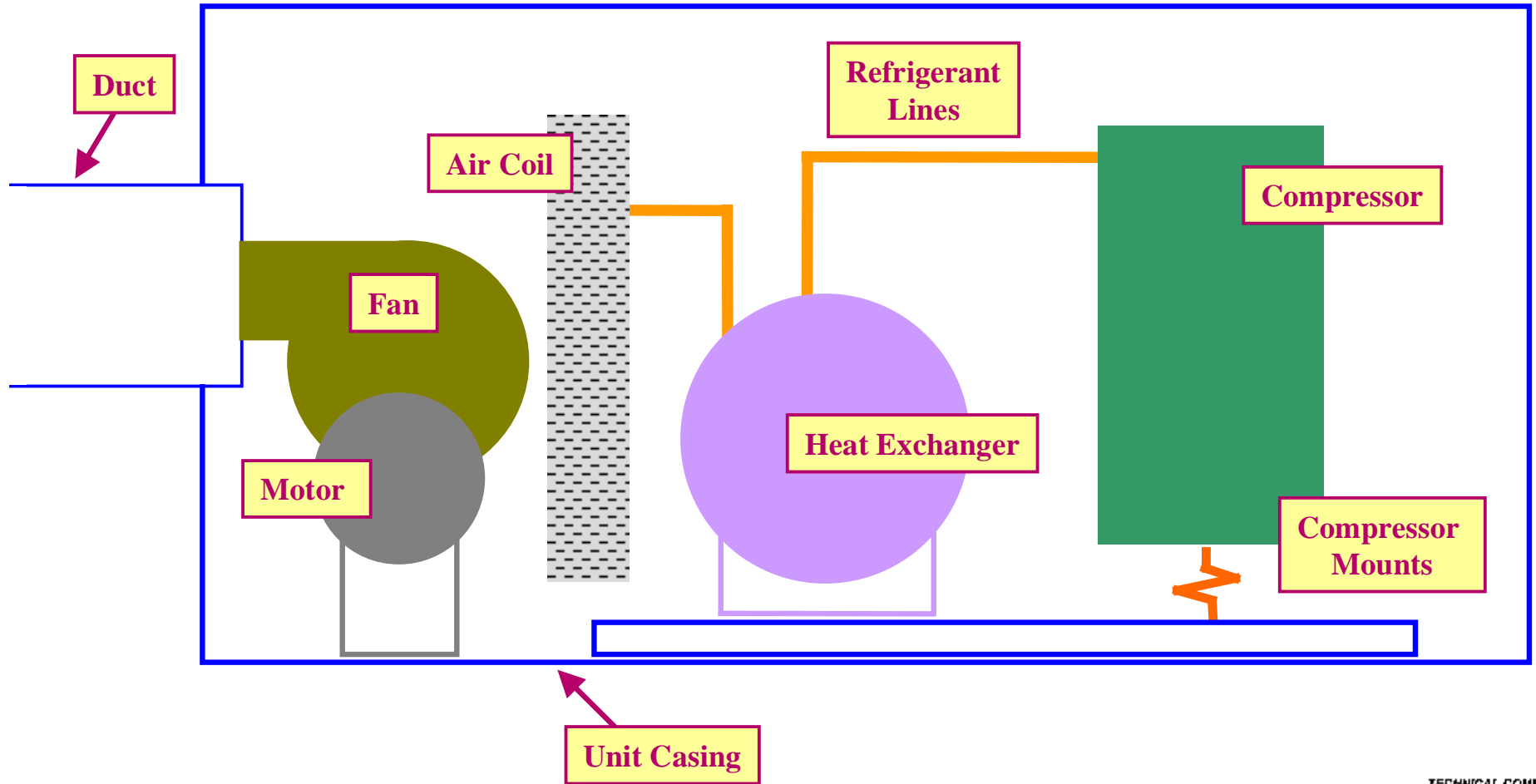
- | **Fans**
 - » FC centrifugal
 - » Tangential

- | **Motors**
 - » Standard single- or three-phase
 - » Variable speed (ECM / ICM)

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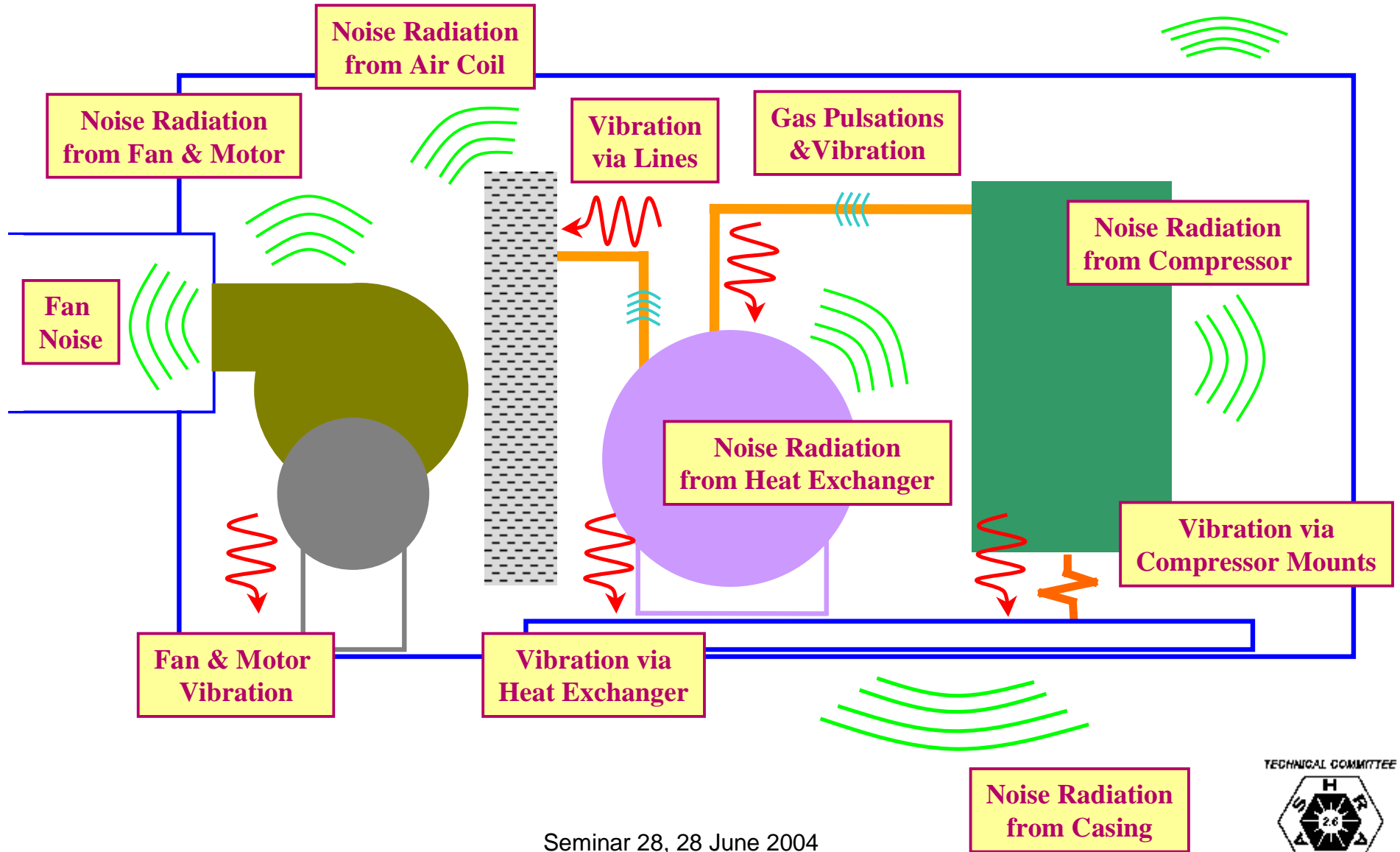
WSHP Unit Schematic



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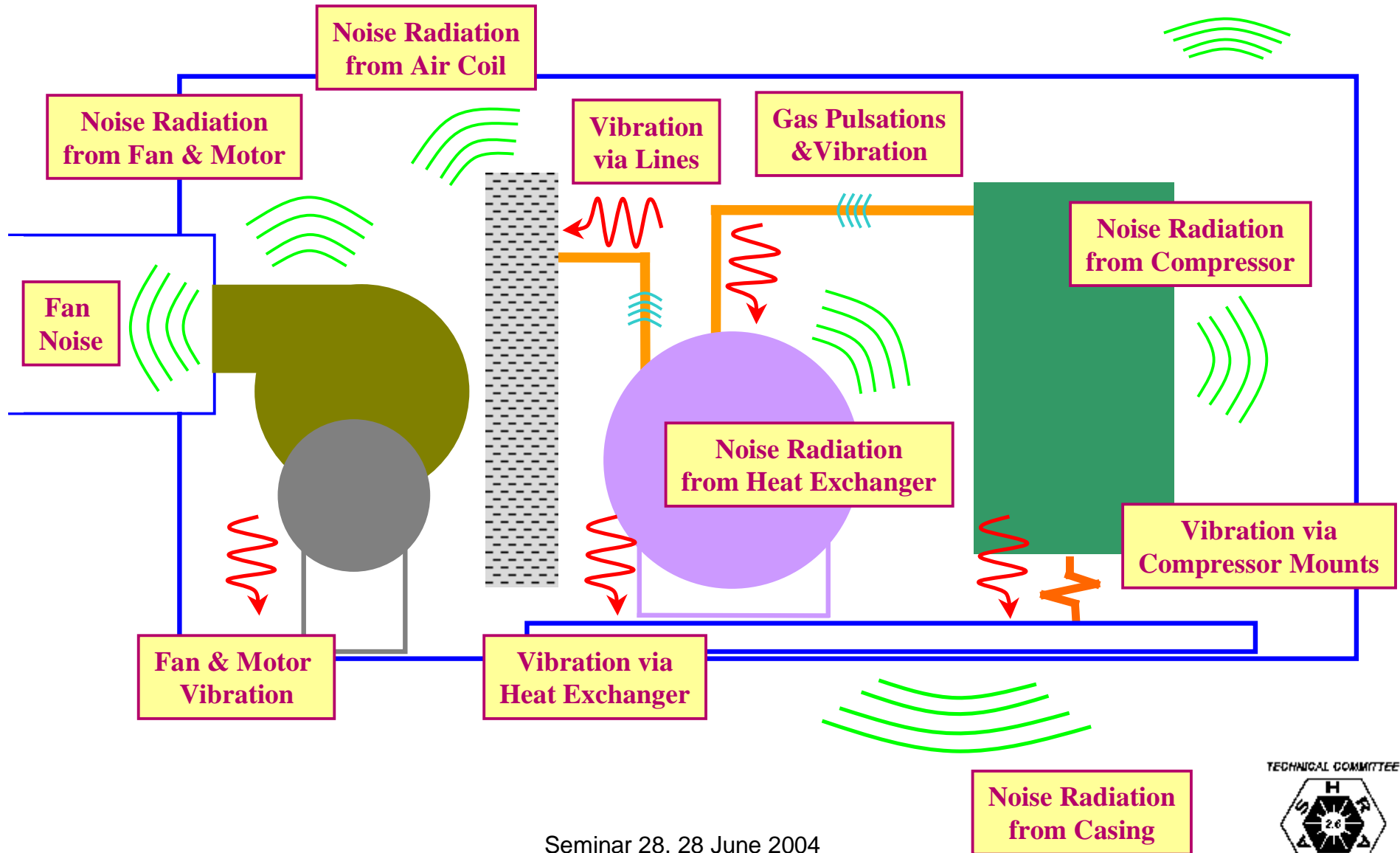
WSHP Noise Generation



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WSHP Noise Generation



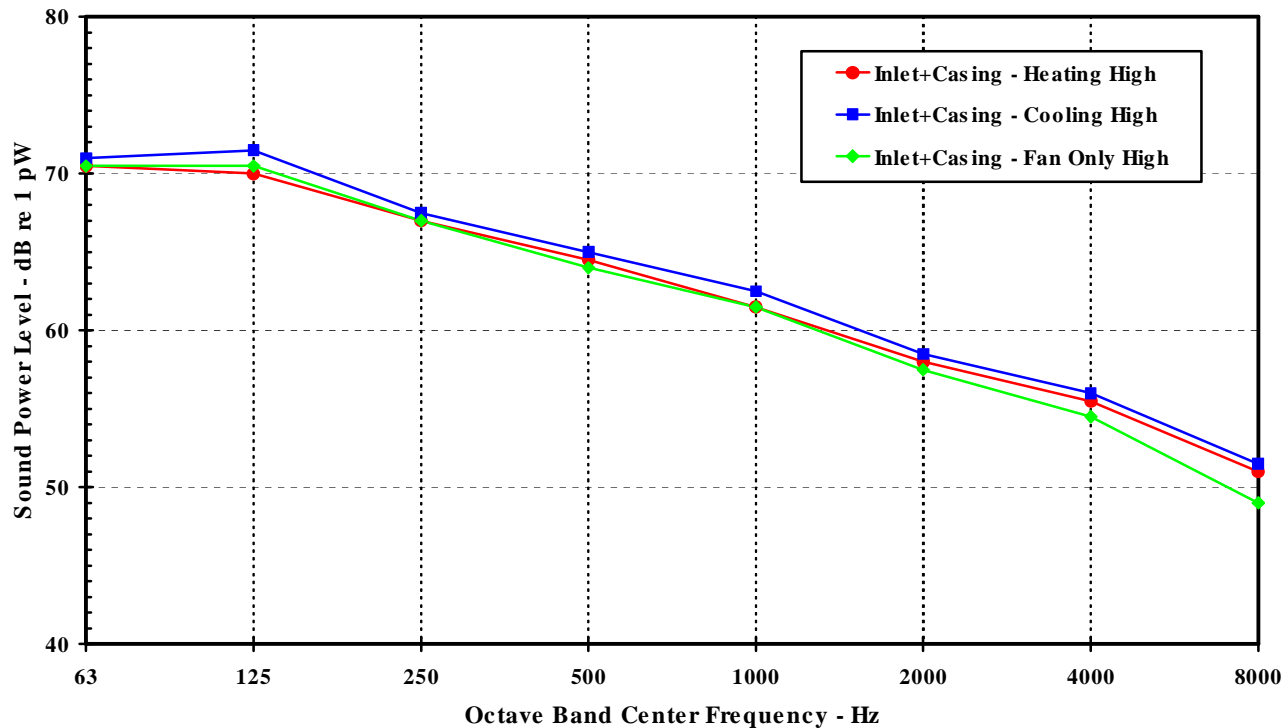
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The Objective

“Balanced” noise spectrum at design target level (dBA, NC, etc.)

- » Compressor tones generally 63 and 120 Hz bands
- » Motor tones 2x electrical – USA 120 Hz is predominant
- » Fan tones blade passing (number x rpm)

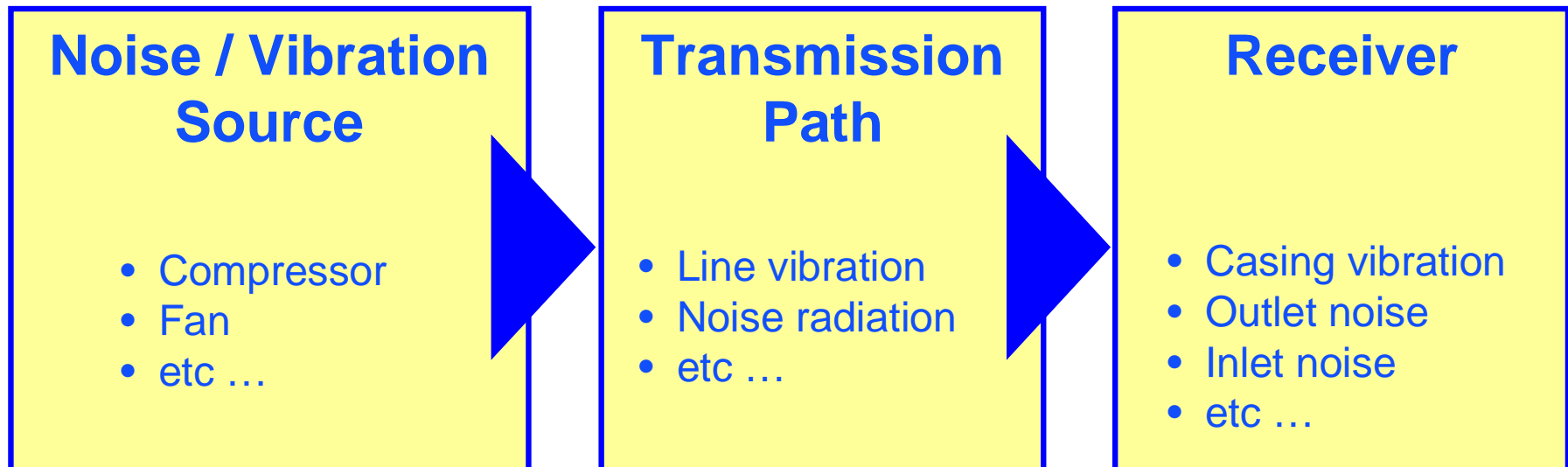


Design challenge: multiple paths and sources at each frequency

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Source – Path – Receiver Model



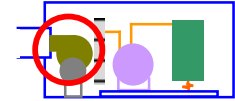
**Select components
for low “excitation”**

**Design unit
configuration
to minimize
transmission**

**Design casing
to minimize
radiation**

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Fan Selection



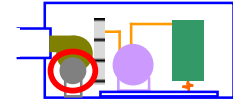
- | **Balance air flow / static performance and noise**
 - » **Test alternatives across full unit operating map**
 - » **Key design parameters:**
 - Diameter
 - Width / diameter aspect ratio
 - Housing “expansion” (scroll design)
 - Wheel / housing “cutoff” spacing – critical for Tangentials
 - » **Unit interaction effects**
 - Clearance between fan and cabinet can be critical

Goal: optimize fan & casing for noise, performance and cost

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Motor Selection



| Fan / motor system evaluation

» Key challenges:

- Speed control: match motor to unit load
 - | variable speed motors (ECM / ICM) great but expensive

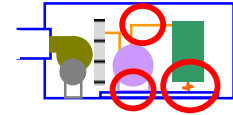
- Control tonal noise at electrical frequencies (120 Hz, 240 Hz, ...)
 - | three phase motors easier to control than single phase
 - | tight control of rotor / stator eccentricity
 - | design rotating parts to shift resonances away from excitation
 - | design motor mounts, housing and/or unit to shift resonances

Goal: meet speed requirements without sacrificing noise or cost

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Unit Design for Compressor Path Control



| Direct Noise Radiation

- » Cabinet insulation
- » Casing thickness / mass
- » Separate enclosures
- » Acoustic blankets

noise absorption
sheet metal gauge
extra box
soft cover

| Vibration Transmission

- » Stiff supports under isolators
- » Refrigerant line “tuning”
- » Refrigerant line mufflers
- » Vibration damping treatment
- » Casing thickness / mass
- » “Double” isolation
- » Isolation of auxiliaries

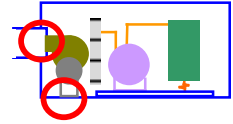
casing structure
resonance & stiffness
especially for recip’s
added or integral
sheet metal gauge
2nd layer of mounts
heat exchangers / coils

Design challenge: treatment effectiveness depends on configuration

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Unit Design for Fan and Motor Path Control



| Direct Noise Radiation

- » Cabinet insulation
- » Casing thickness / mass
- » Coil selection and placement

noise absorption
sheet metal gauge
blow vs. draw through

| Vibration Transmission

- » Motor isolators
- » Stiff supports under motor and fan

metal / elastomeric
casing structure

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Steps to Successful Design

- | **Define unit noise requirements**
 - | NC, sound power, relative to competition ...
 - | Operating air flow and static range (entire envelope)
 - | Establish cost benefit: what is the value of low noise ?

- | **Select major components**
 - | Compressors, motors, fans, coils – performance tests

- | **Tailor system configuration to control paths**
 - | Systematic tests / analyses to identify and control key areas

- | **“De-tune” system as needed to control resonances**
 - | Refrigerant lines
 - | Fan / motor system
 - | Others as needed

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Noise Control in WSHP Design: The Future

- | **Increasingly strict noise requirements**
 - » Awareness
 - » Classroom standard
 - » Internationalization

- | **Improved components**
 - » Low noise compressors
 - » Programmable motors
 - » Low noise fans

- | **Increased use of noise prediction technology in design**
 - » Finite Element / Boundary Element / Statistical Energy models

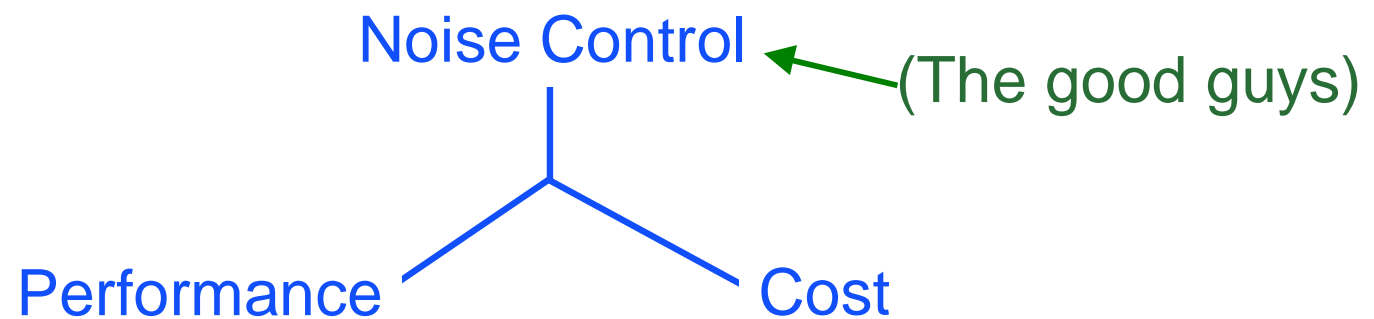
- | **Alternate configurations**
 - » Alternate casing materials and structural design
 - » New unit space envelopes / component arrangements

Noise no longer an afterthought: it must be designed in

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The Age Old Struggle!



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